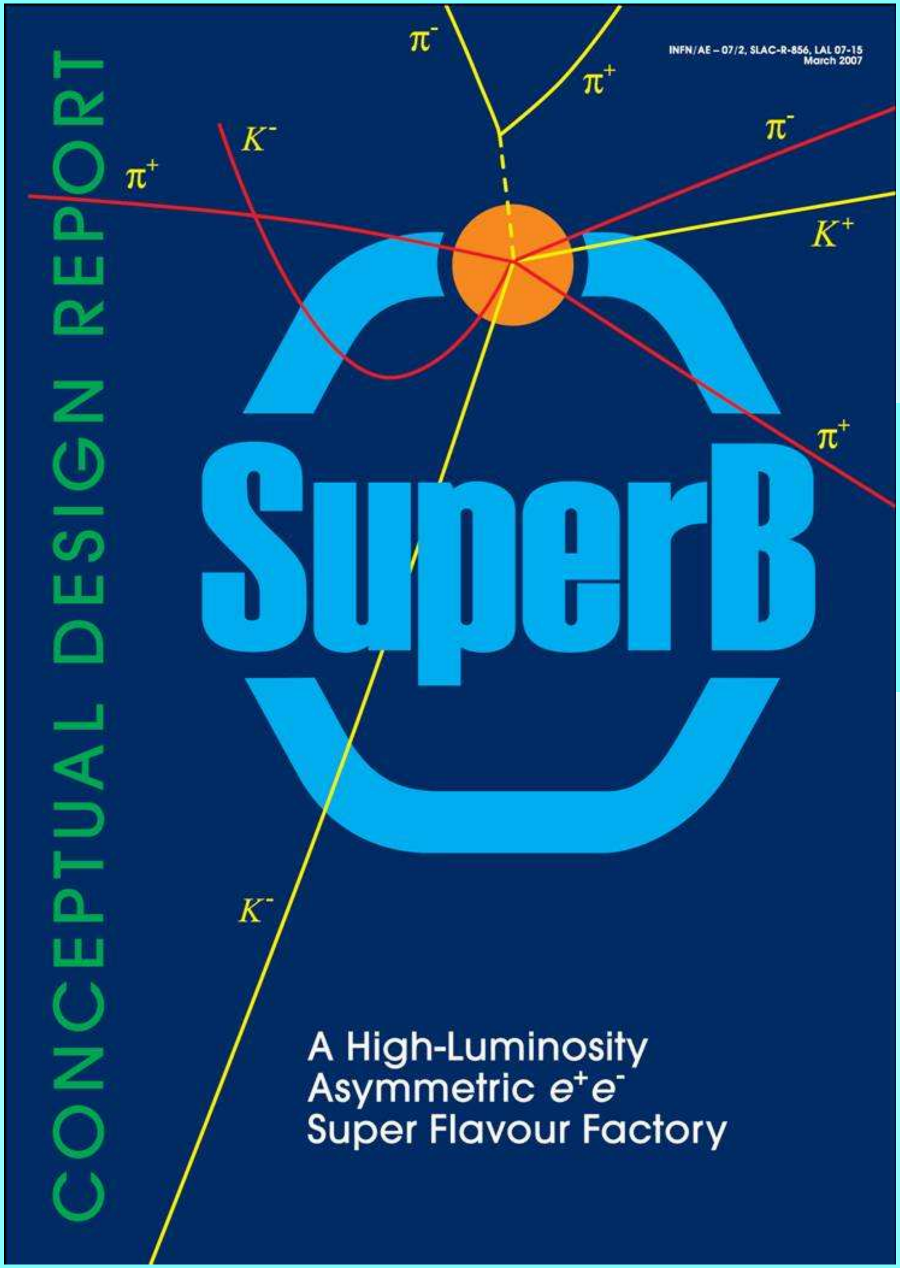


-Factory

M. Biagini, LNF-INFN
for the SuperB Team

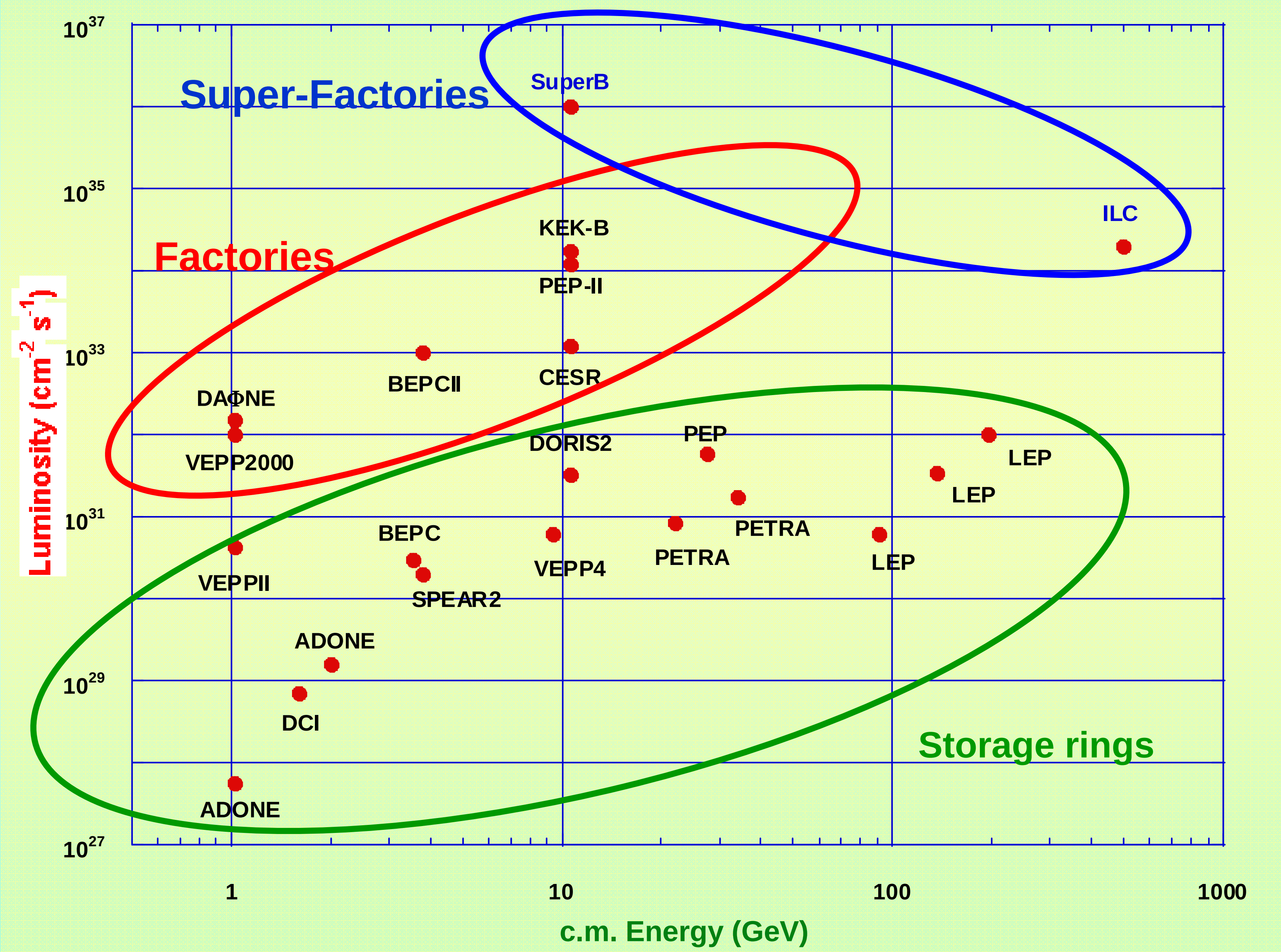
Accelerator R&D and Technology,EPS

Manchester, July 20, 2007

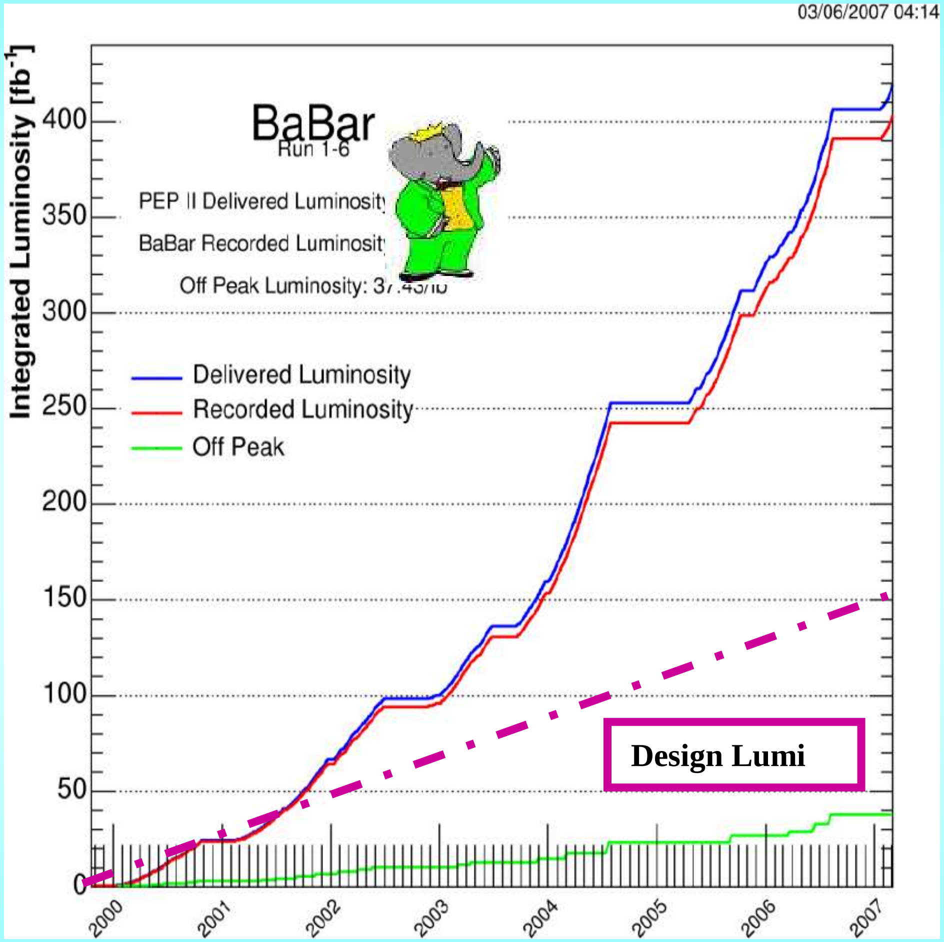
Why a SuperB-Factory?

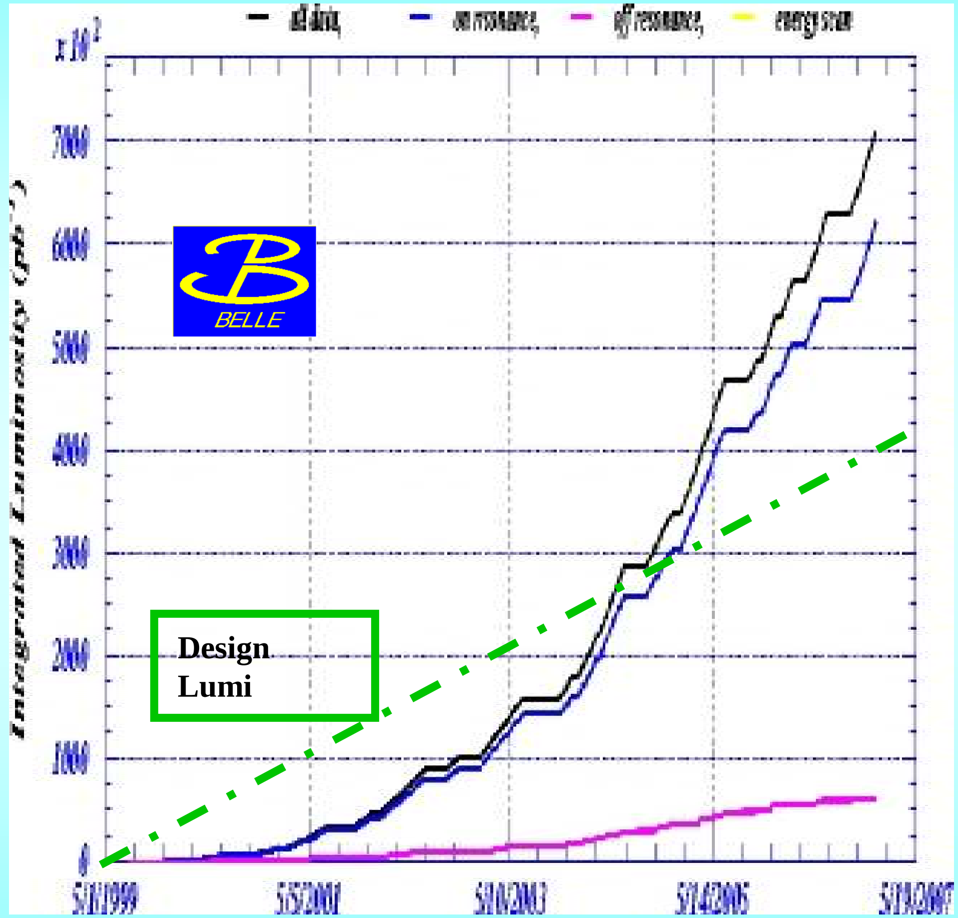
- B-factories (PEP-II and KEKB) have exceeded their design goals, both in peak and integrated luminosity
- High operation reliability and performances represent a success for all factories (at lower energy too: DAΦNE)
- Upgrade of an order of magnitude and more in Luminosity are highly desirable for investigation on Physics beyond the Standard Model

$e^+ e^-$ colliders



Extraordinary success of B-Factories





PEP-II (BaBar), 400 fb^{-1}

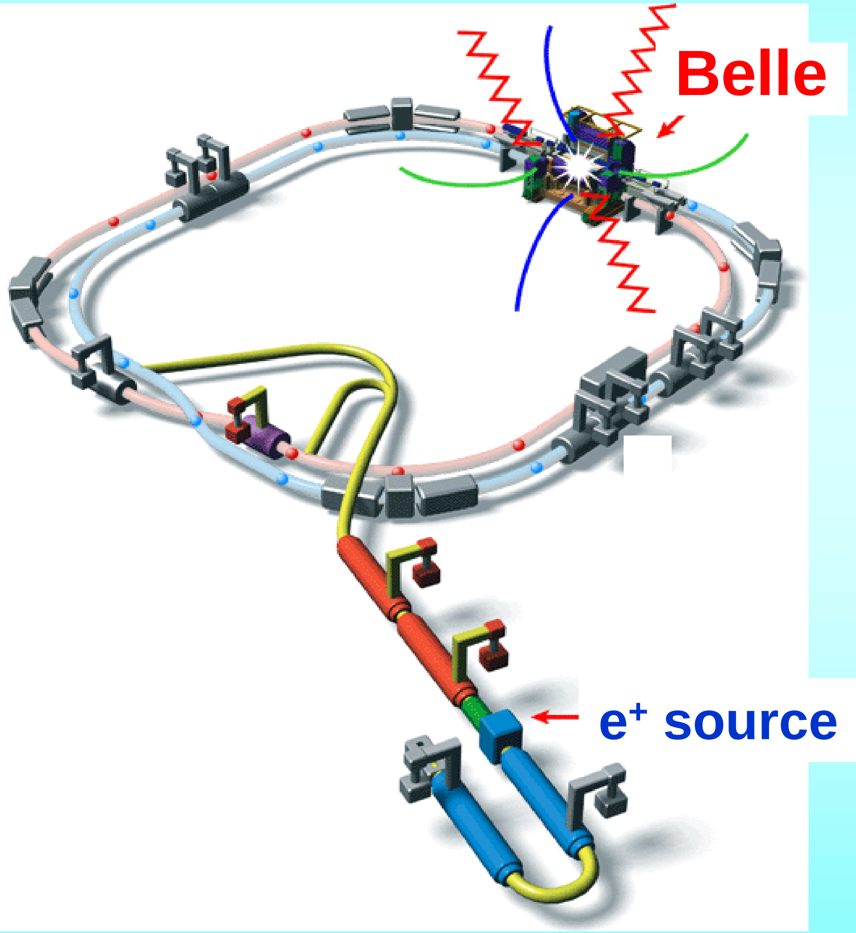
KEKB (Belle), 710 fb^{-1}

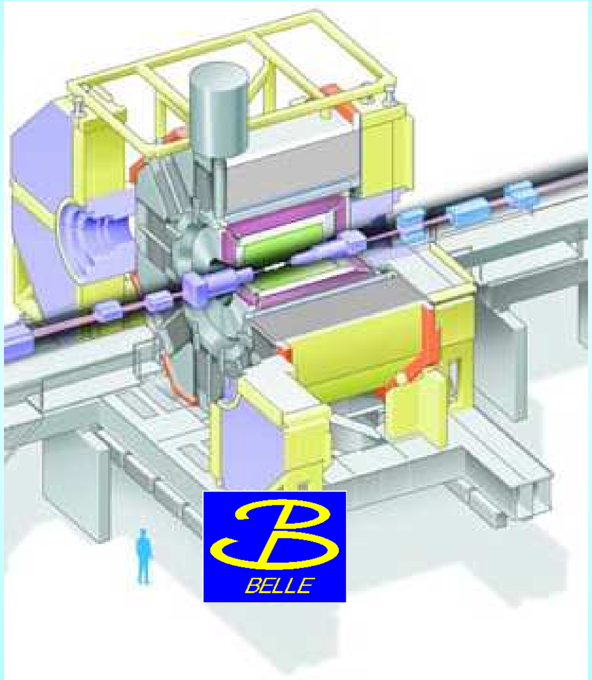
Total > 1.1 ab^{-1}

KEKB

8 (e^-) x 3.5 (e^+) GeV
22 mrad crossing angle

13 countries,
57 institutions,
~400 collaborators





Since 1999: **710 fb^{-1}**

Peak Luminosity:

$1.7 \times 10^{34}\ cm^{-2}\ s^{-1}$

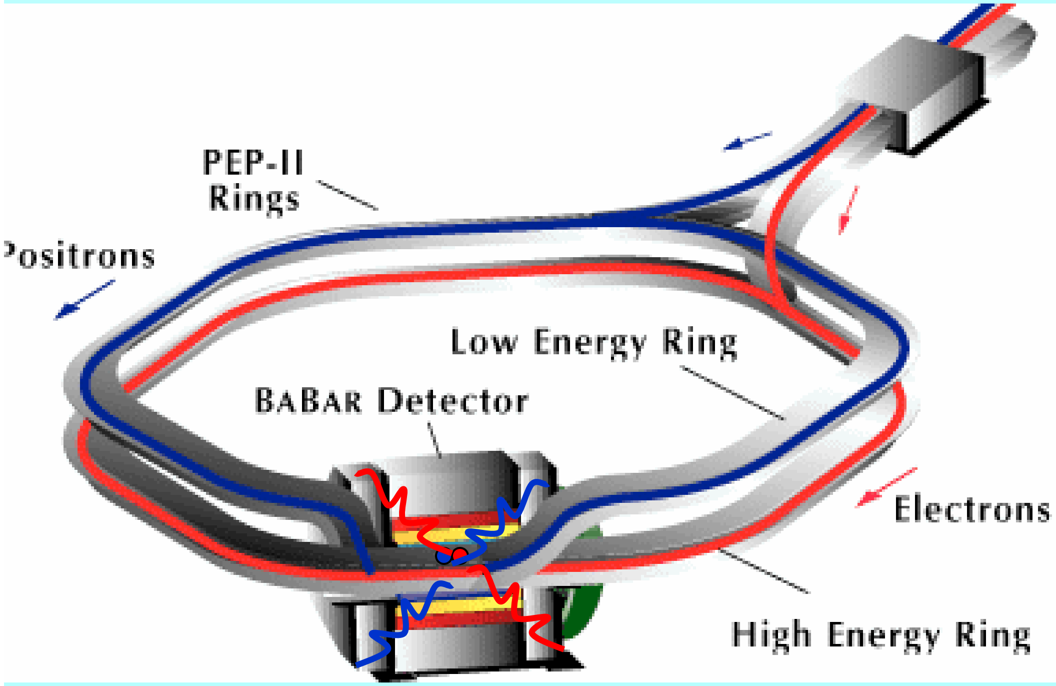
1662 mA (LER) , 1340 mA (HER)

1389 bunches

PEP-II

9 (e^-) x 3.1 (e^+) GeV
no crossing angle

11 countries,
80 institutions,
~630 collaborators



Since 1999: **400 fb^{-1}**

Peak Luminosity:

1.2×10^{34} cm^{-2} s^{-1}

2900 mA (LER) , 1875 mA (HER)

1722 bunches

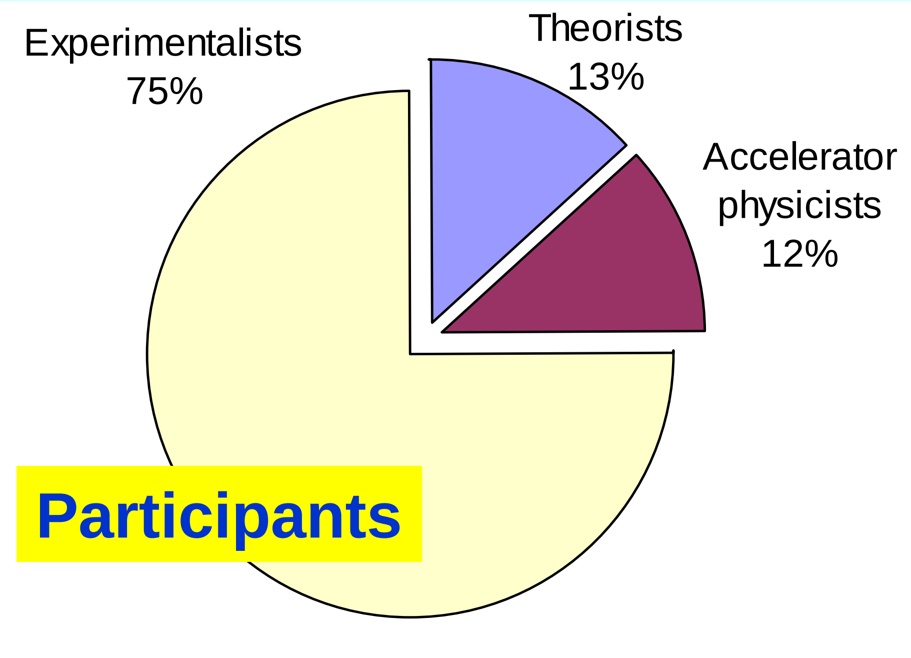
The SuperB Process

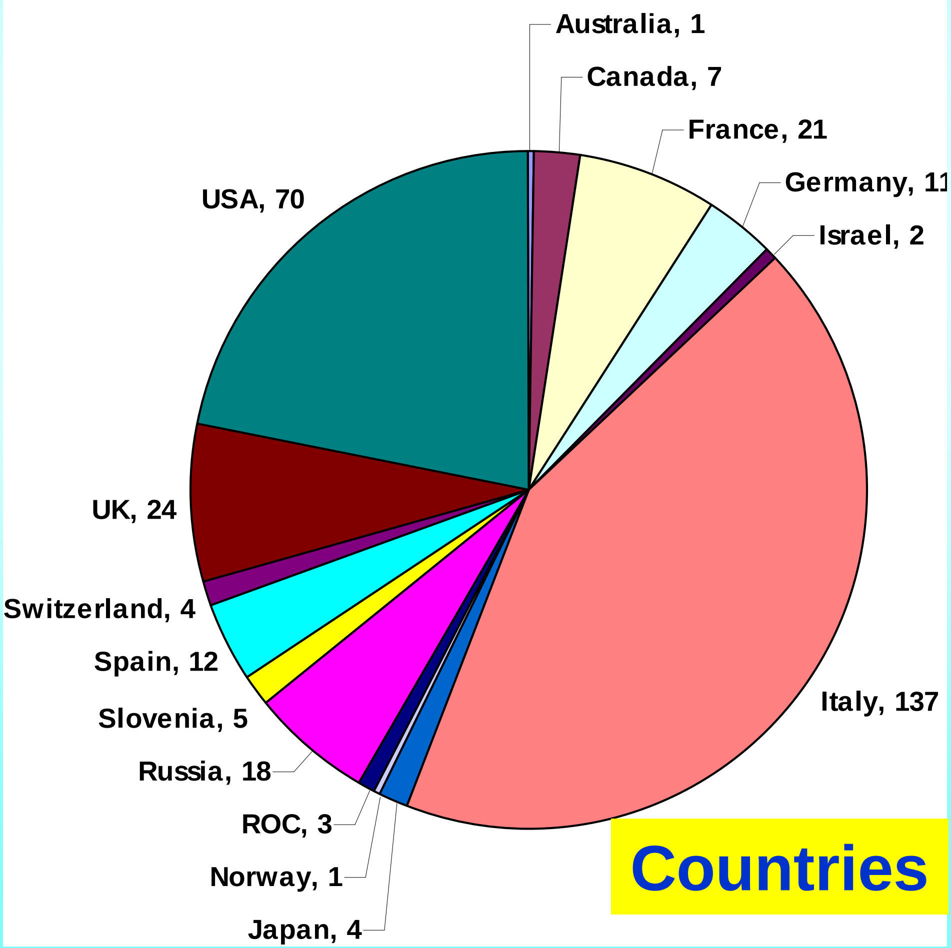
- International SuperB Study Group on
  - Physics case, Machine, Detector
- International steering committee established, chaired by M. Giorgi. Members from
  - Canada, France, Germany, Italy, Russia, Spain, UK, US
  - Close collaboration with Japan, although not formalized
- Regular workshops
  - Five workshops held at SLAC, Paris, Frascati
  - SuperB Meeting at Daresbury
  - Accelerator retreat at SLAC (next one in Sep. 2007)
- Conceptual Design Report
  - Published in March
  - Describes Physics case, Accelerator, Detector, including costs
  - International Review Committee in October 2007
- More information: www.pi.infn.it/SuperB

The SuperB Effort

"Conceptual Design Report" (450 pp), March 2007
INFN/AE-07/2,SLAC-R-856, LAL 07-15
www.pi.infn.it/SuperB/?q=CDR

- 320 CDR signatures
- 85 Institutions
- 239 Experimentalists





How to increase L ?
(example Super-KEKB)

Stored current:

x 3 (HER) / x 5 (LER)

Beam-beam parameter:

x 4

Lorentz factor

$$L = \frac{\gamma_{\pm}}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\frac{I_{\pm}\xi_{\pm y}}{\beta_y^*}\left(\frac{R_L}{R_y}\right)$$

Classical electron radius

Beam size ratio

Geometrical reduction factors due to crossing angle and hour-glass effect

Luminosity:

x 50

Vertical β at the IP:

x 0.5

How to increase L ? (cont)

“Brute force” method

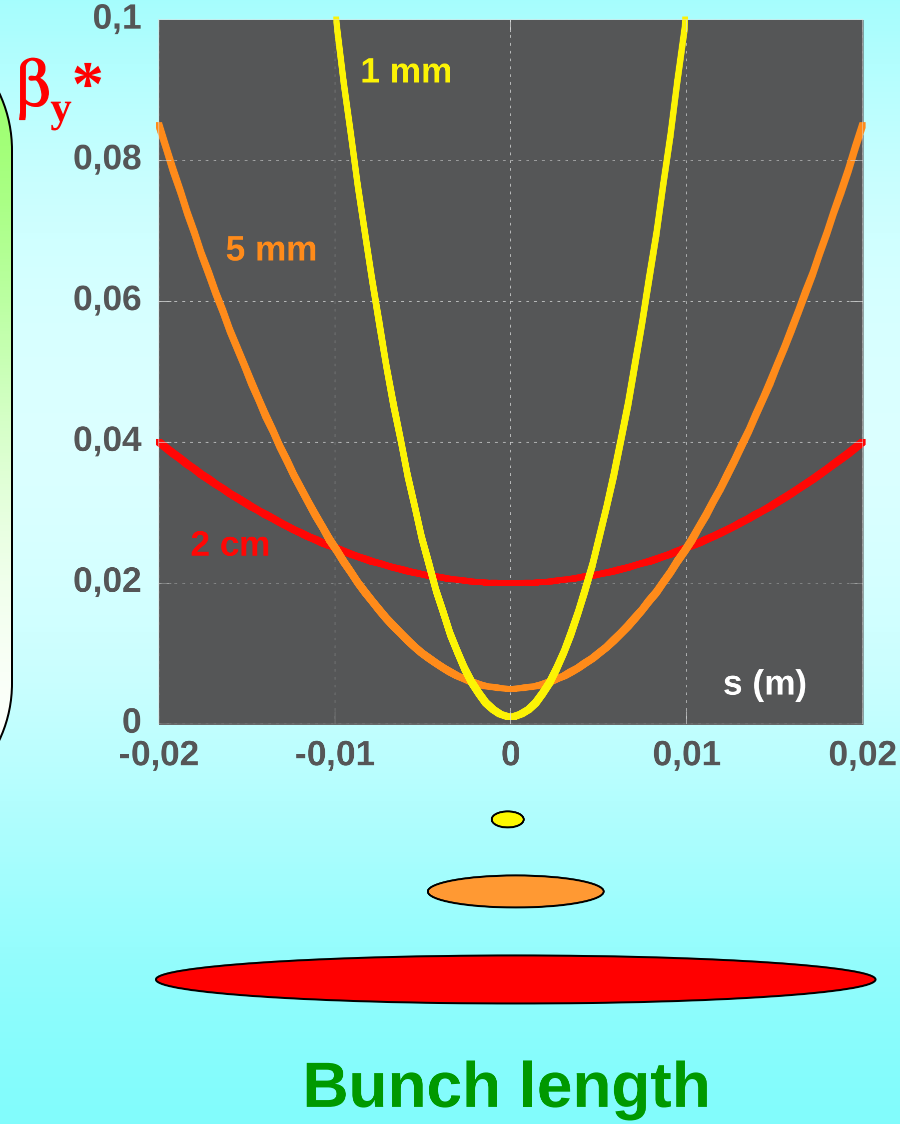
- Increase beam currents
- Decrease β_y^*
- Decrease bunch length

But...

- HOM in beam pipe
  - *overheating, instabilities, power costs*
- Detector backgrounds increase
- Chromaticity increase
  - *smaller dinamic aperture*
- RF voltage increase
  - *costs, instabilities*
- Shorter LER Touschek lifetime

Hourglass effect

To squeeze the vertical beam dimensions, and increase L, β_y at IP must be decreased. This is efficient only if at the same time the bunch length is shortened to ≈ β_y value, or particles in the head and tail of the bunch will see a larger β_y.



Summary from Oide's talk at 2005 2nd Hawaii Joint SuperB-Factory Workshop

- Present design of SuperKEKB hits fundamental limits in the beam-beam effect and the bunch length (HOM & CSR).
- Higher current is the only way to increase the luminosity.
- Many technical and cost issues are expected with a new RF system.
- **We need a completely different collider scheme...**

K. Oide, Summary, 2nd Joint SBF Workshop, April 2005

A new idea...

P. Raimondi's idea to focus more the beams at IP and have a "large" crossing angle → large Piwinski angle

- Ultra-low emittance (ILC-DR like)
- Very small β at IP
- Large crossing angle
- "Crab Waist" scheme

Test at DAΦNE next Fall !!!

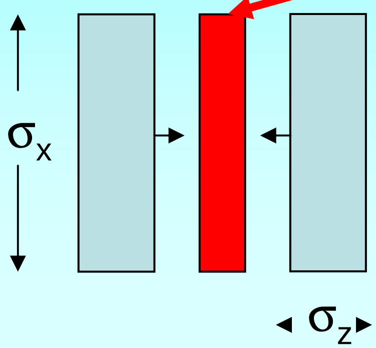
- Small collision area
- Lower β is possible
- NO parasitic crossings
- NO synchro-betatron resonances due to crossing angle

Large crossing angle, small x-size

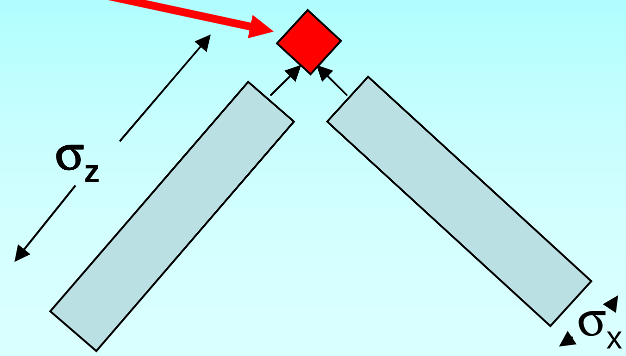
1) Head-on, Short bunches

Overlap region

2) Large crossing angle, long bunches



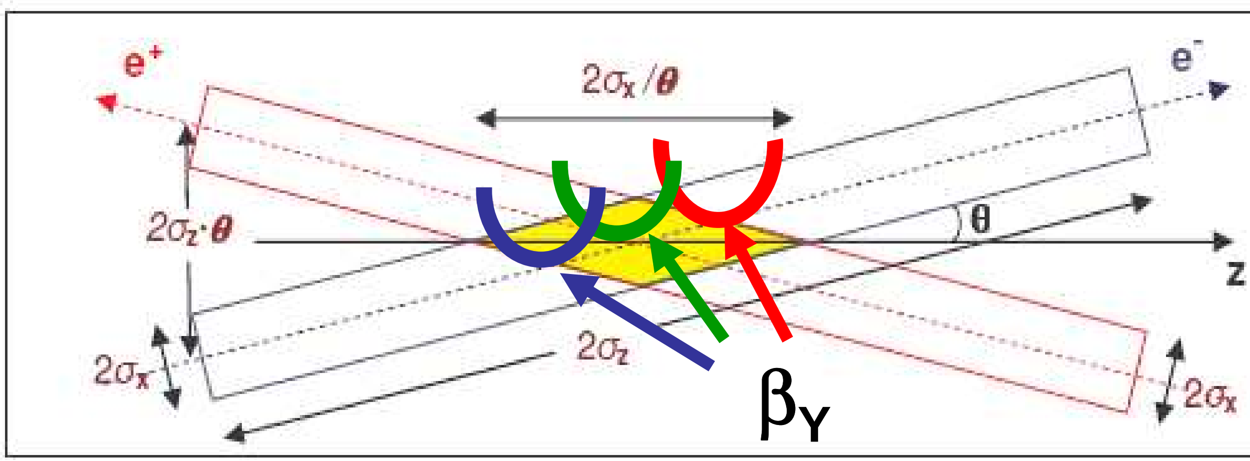
(1) and (2) have same Luminosity, but (2) has longer bunches and smaller σ_x



With large crossing angle the x and z planes are swapped

Large Piwinski angle:

$\Phi = tg(\theta)\sigma_z/\sigma_x$



y waist can be moved along z with a sextupole on both sides of IP at proper phase

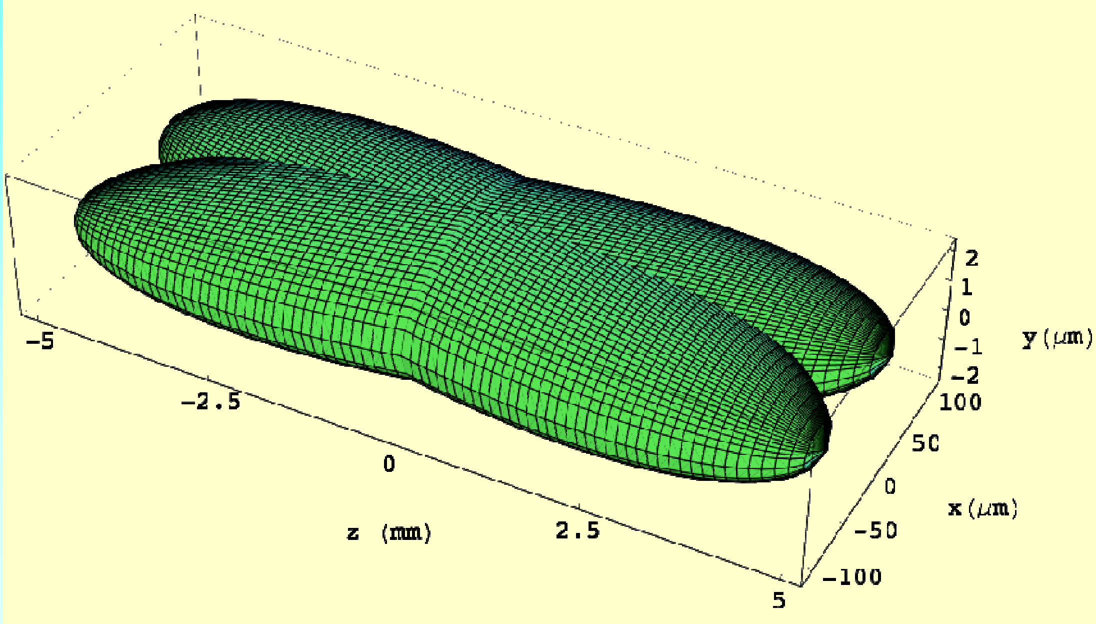
"Crab Waist"

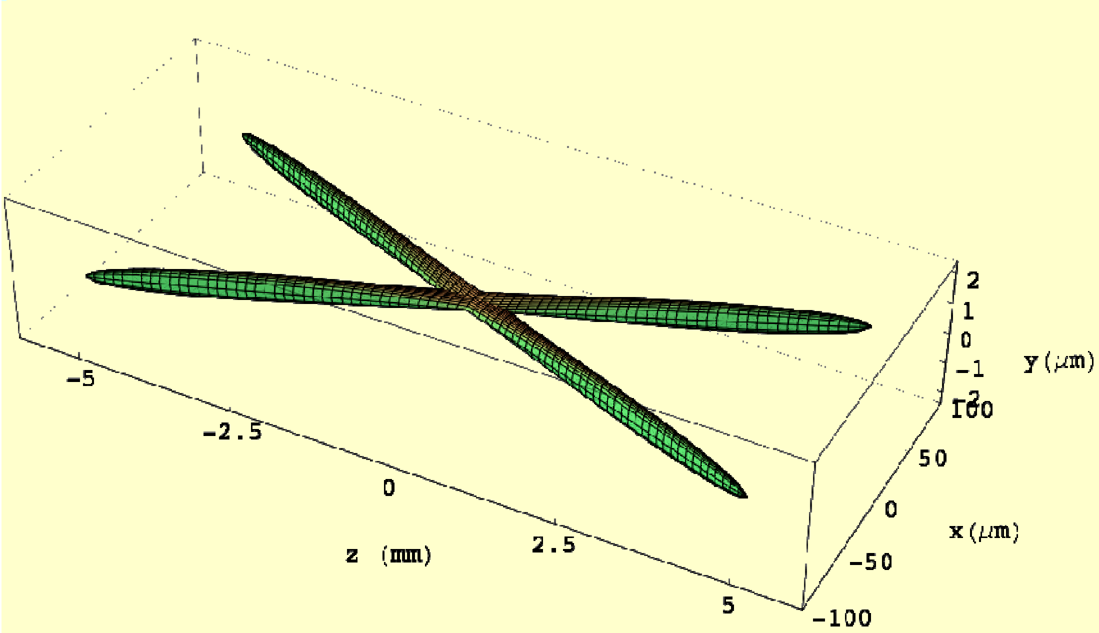
... and ...

- Higher luminosity with same currents and bunch length:
  - Beam instabilities are less severe
  - Manageable HOM heating
  - No coherent synchrotron radiation of short bunches
  - No excessive power consumption

- Lower beam-beam tune shifts
- Relatively easier to make small σ_x w.r.t. short σ_z
- Problem of parasitic collisions becomes negligible due to higher crossing angle and smaller σ_x

IP beam distributions for KEKB





IP beam distributions for SuperB

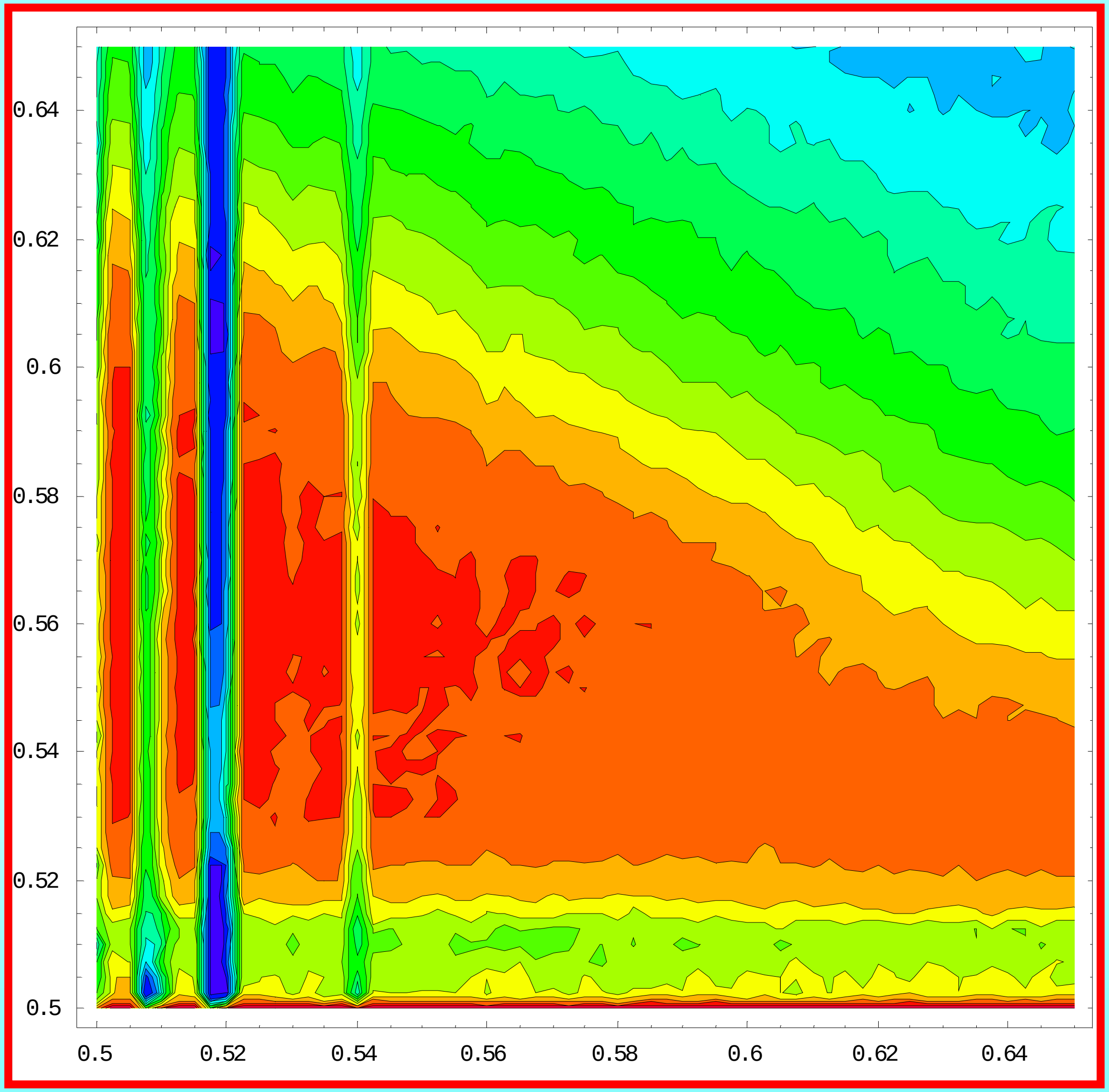
An example...

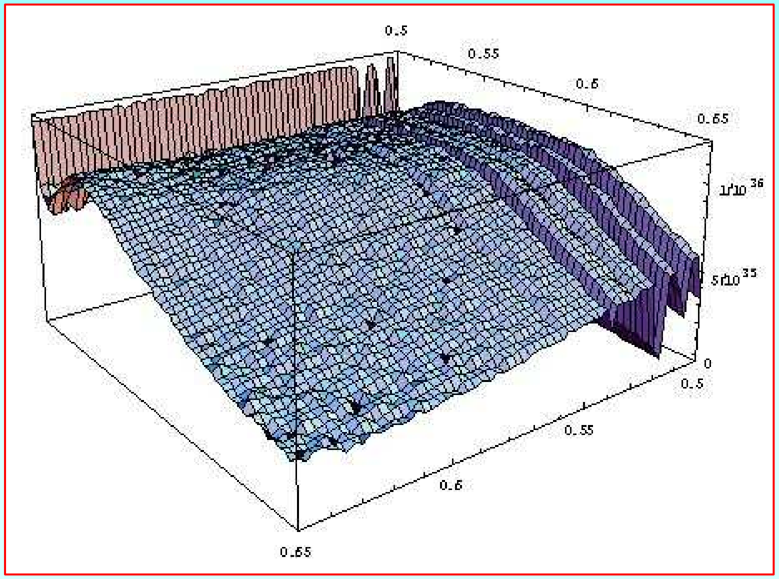
	KEKB	SuperB
I (A)	1.7	2.
β_y^* (mm)	6	0.3
β_x^* (mm)	300	20
σ_y^* (μm)	3	0.035
σ_x^* (μm)	80	6
σ_z (mm)	6	5
L ($cm^{-2}s^{-1}$)	1.7×10^{34}	$1. \times 10^{36}$

Here is Luminosity gain

Luminosity vs tunes scan

(P. Raimondi, D. Shatilov, M. Zobov)

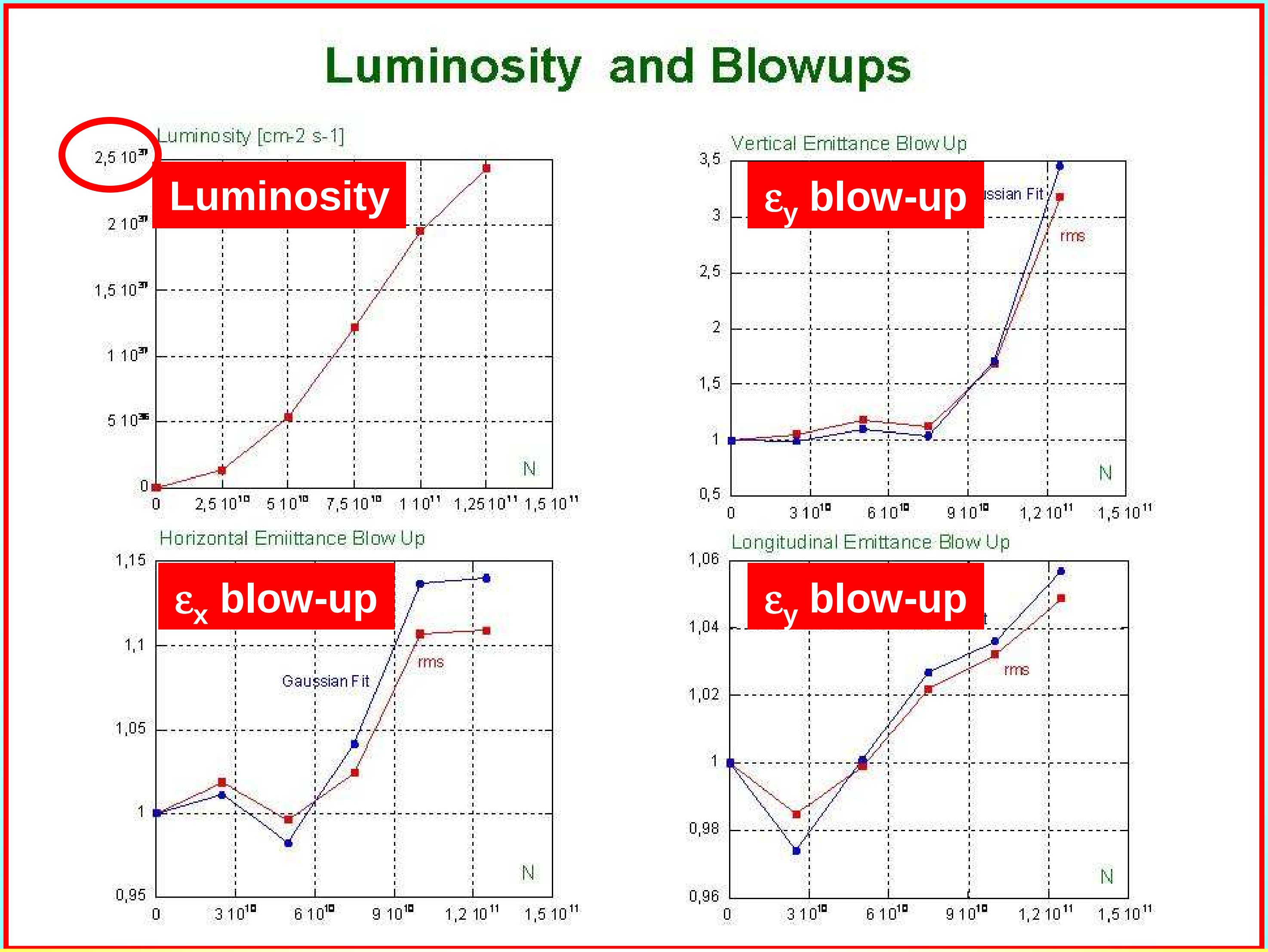




- Individual contours differ by 10% in luminosity
- Design luminosity can be obtained over a wide tune area

(horizontal axis - ν_x from 0.5 to 0.65; vertical axis – ν_y from 0.5 to 0.65)

Luminosity vs bunch population

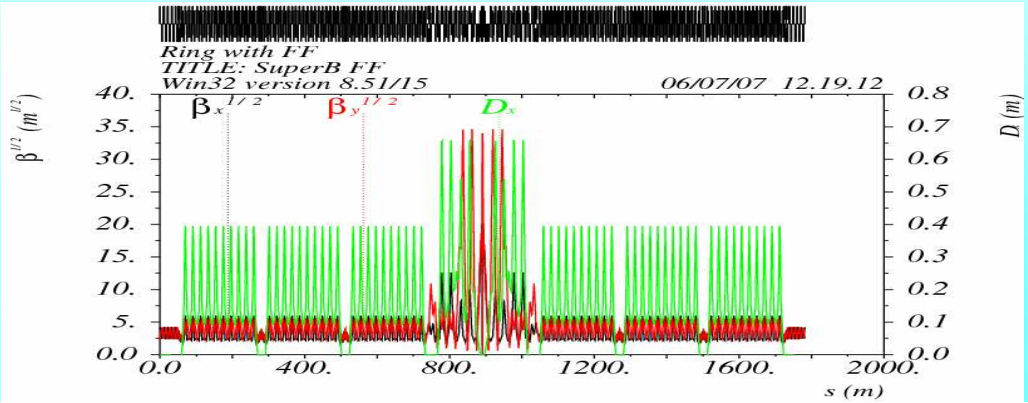


Luminosity grows quadratically with bunch population till about 7.5x10^{10} particles/bunch, with no blow-up

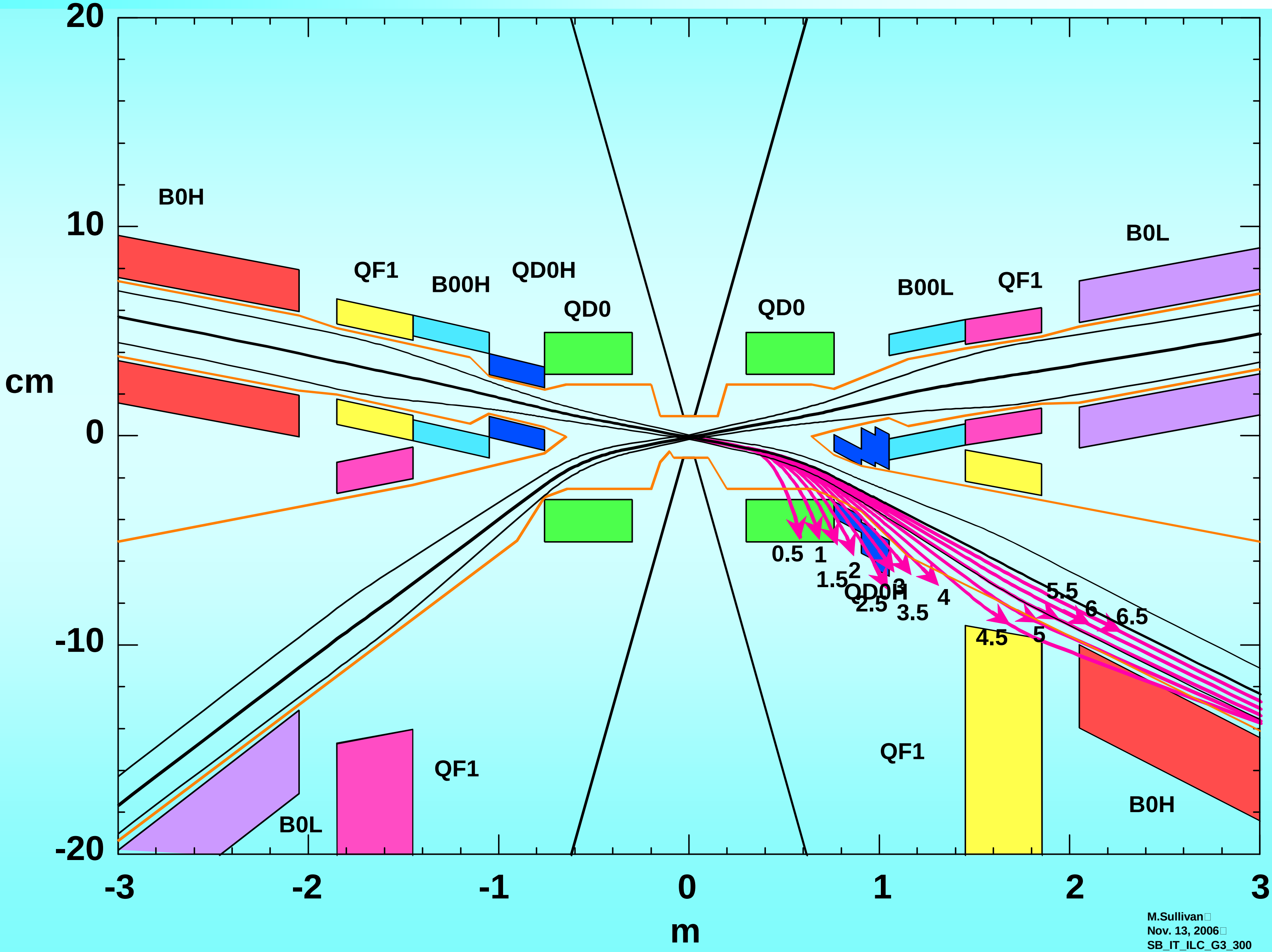
The Rings

- Two rings @ 4 and 7 GeV with one Interaction Region where Super-BaBar detector will be installed
- Ring characteristics similar to ILC Damping Rings → synergy

- “Final Focus” section FFTB/ILC-like
- Design based on recycling all PEP-II hardware, magnets, and RF system
- Total power: 12 MW, lower than PEP-II



Interaction Region Layout

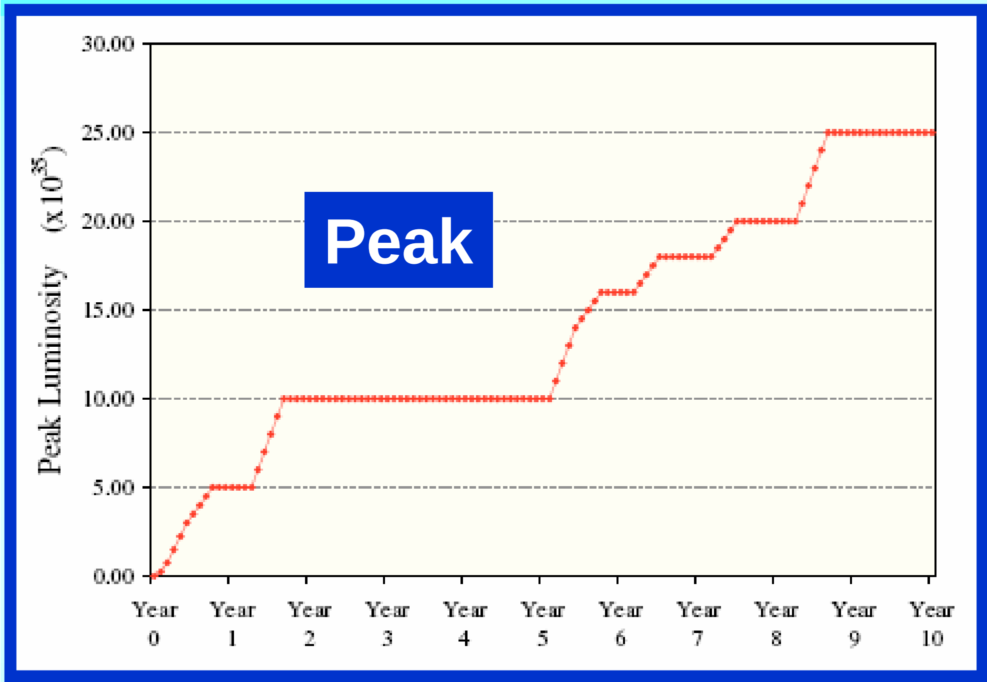


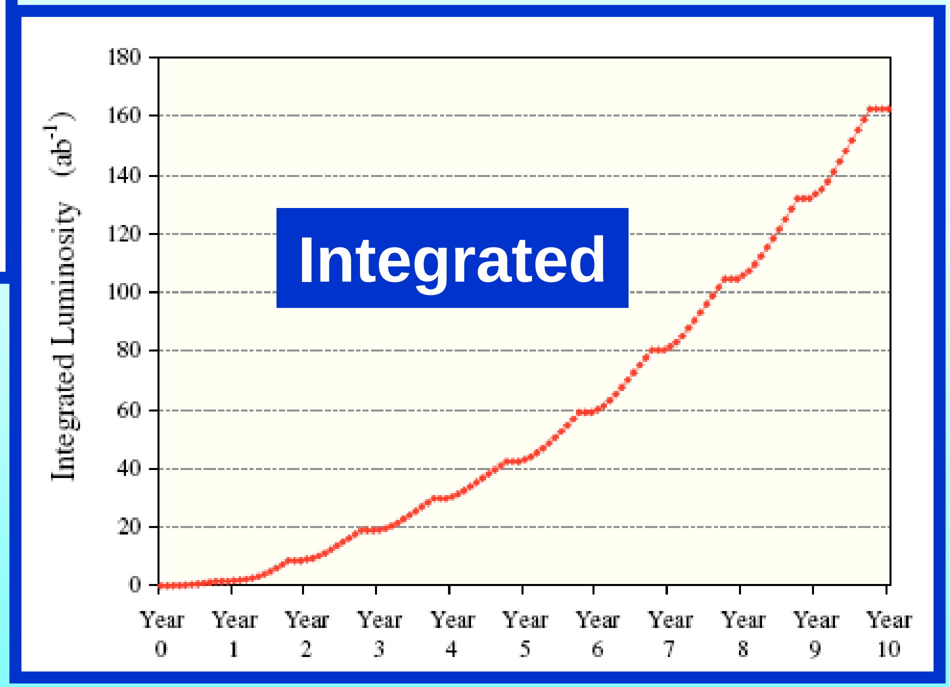
M.Sullivan
Nov. 13, 2006
SB_IT_ILC_G3_300

SuperB Parameters

Circumference (m)	1780.
Energy (GeV)	4 + 7
Current (A)	2.
No. bunches	1342
No. part/bunches	5.5×10^{10}
θ (rad)	2x24
ε_x (nm-rad)	1.6
ε_y (pm-rad)	4.
β_y^* (mm)	0.3
β_x^* (mm)	20
σ_y^* (μm)	0.035
σ_x^* (μm)	6
σ_z (mm)	5
RF Power (MW)	12
L ($cm^{-2}s^{-1}$)	**$1. \times 10^{36}$**

SuperB estimated Luminosity





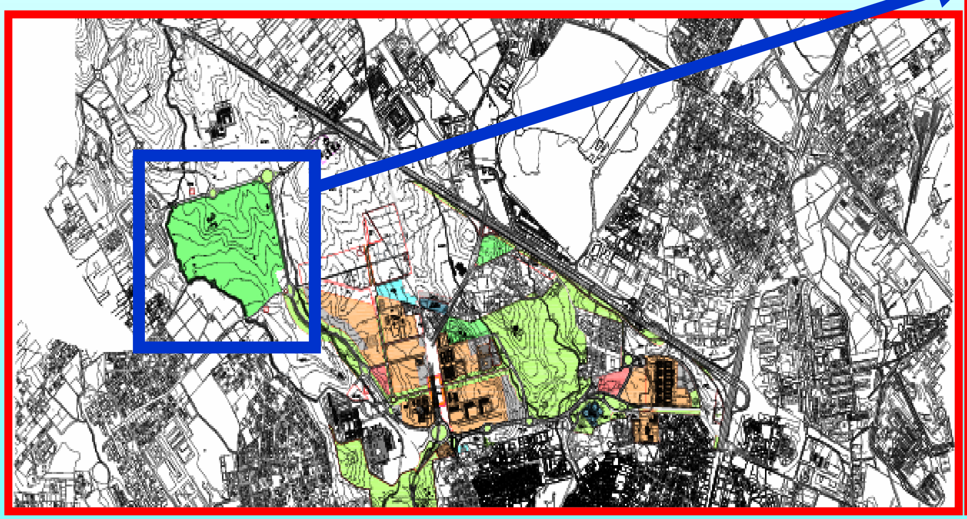
PEP-II: Magnets and RF system are re-usable for SuperB and will be provided by SLAC (negotiations in progress)

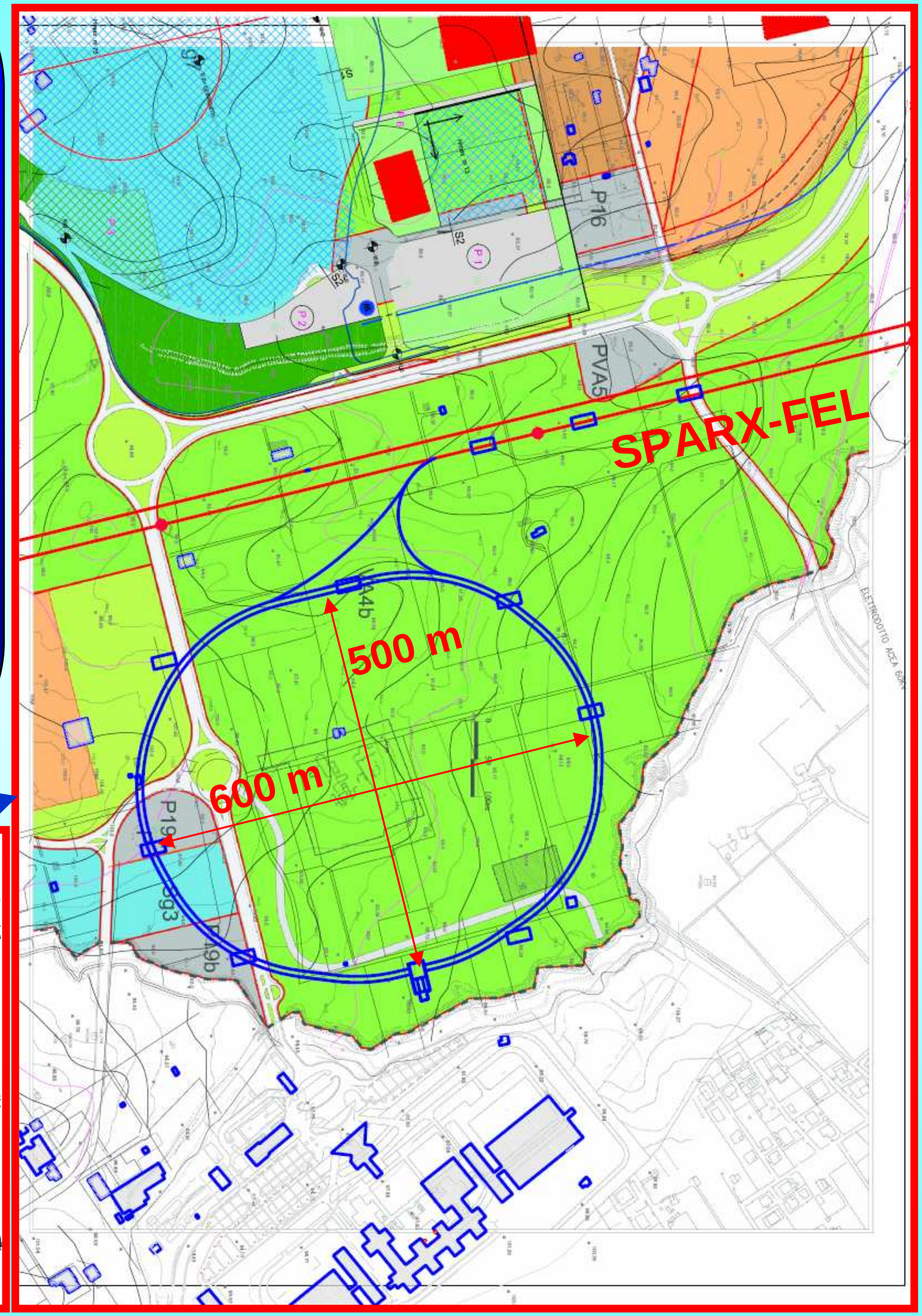
Where? One possible site:
Tor Vergata University Campus
near Frascati

- Available area belongs to Tor Vergata University

- Physicists & engineers are working for site and infrastructures

in synergy with the SPARX-FEL project, approved and funded





Cost estimate

- Separate new components from reused elements
  - Replacement value of reused components (extrapolated from PEP-II costs)
  - New costs: everything that's needed today, including refurbishing
  - Transport is not included, but disassembly and reassembly is
- Accelerator approximated cost : 190 Meuros
  - Not tried to fully optimize the cost yet
- Clearly the SuperB Project is inherently international and will need to be managed internationally
- All details available in the CDR

What money ?

- The SuperB budget model still needs to be fully developed. It is based on the following elements (all being negotiated)
  - Italian government ad hoc contribution
  - Regione Lazio contribution
  - INFN regular budget
  - EU contribution
  - In-kind contribution (PEP-II + BaBar)
  - Partner Countries contributions
- Clearly the SuperB Project is inherently international and will need to be managed internationally

Conclusions I

New large Piwinski angle scheme will allow for peak luminosity $\geq$ **10^{36} cm^{-2} s^{-1}** **well beyond the current state-of-the-art**

without a significant increase in beam currents or shorter bunch lengths

- Use of "*crab waist*" sextupoles will add a bonus for suppression of dangerous resonances.
- Test at DAΦNE will help in discovering possible issues.

Conclusions II

- There is a growing international interest and participation
- R&D is proceeding on various items

- A conceptual design report is ready for review by the International Review Committee
- Next issues are: **site, money**